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Stephen J. Brenner

Joel G. Jorgensen

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Stephen J. Brenner[1,3] and Joel G. Jorgensen[2]

[1]Audubon Nebraska, Gering, NE 69341
[2]Nongame Bird Program, Nebraska Game and Parks Commission, 2200 N. 33rd, Lincoln, NE, 68503
[3]Corresponding author; stephen.brenner@audubon.org

Introduction

The Northern Saw-whet Owl (*Aegolius acadicus;* NSWO) is one of the smallest owls in North America. Once considered a rare sighting in the lower 48 United States, recent banding studies across North America have increased the overall knowledge about the species' distribution and occurrence. NSWOs breed in forested regions of the northern United States and southern Canada as well as throughout the Rocky Mountains (Rasmussen et al. 2020). In eastern North America, NSWOs migrate south from northern breeding areas during the late autumn months (Beckett and Proudfoot 2011). Relatively high densities occur around the Great Lakes annually as a result of these movements (Rasmussen et al. 2020). This species also demonstrates cyclical population fluctuations which can result in irruptive flight years during some fall migrations, typically occurring at 3-5 year intervals (Beckett and Proudfoot 2011).

Prior to 2019, records of NSWOs in Nebraska during fall were limited. There were fewer than five accepted reports in eastern Nebraska since the 1950s (Silcock and Jorgensen, 2021). The Hitchcock banding station along the Missouri River bluffs in nearby western Iowa has captured, banded, and released 20-50 birds during autumn migration for a number of years (J. Toll, personal communication). Furthermore, a single season banding study in central Nebraska during fall 2004 captured 14 NSWOs (Kim 2005), suggesting the species may migrate annually over much of the state in fall, or at least in more years than previously thought. This is despite the relative lack of continuous forested habitat in the eastern and central part of the state and extensive areas of agricultural land cover. However, the absence of any systematic effort to detect this species over multiple years, especially away from the Missouri River, renders such conclusions speculative.

To address information gaps, we conducted targeted NSWO banding efforts in the vicinity of Lincoln, Nebraska, for three consecutive years in 2019, 2020, and 2021. Our objectives were to determine 1) whether NSWOs migrate through this area regularly in fall, 2) the phenology of migration through our area, and 3) whether NSWO age classes vary by year. Our results should clarify and define the status of NSWOs' fall movements in eastern Nebraska.

Methods

We used similar methods over all three years. All trapping was conducted at public areas owned by the Nebraska Game and Parks Commission. In 2019 and 2020, we trapped at multiple areas to avoid interfering with other area users (e.g., hunters, hikers) and to assess the feasibility and productivity of different sites. Three sites were in Lancaster County, Nebraska: Branched Oak State Recreation Area (SRA), Pawnee Lake SRA and Conestoga Lake Wildlife Management Area (WMA). Our final site was Oak Glen WMA in eastern Seward County. All sites were within 25 km (~15 miles) of each other. Branched Oak SRA eventually became our primary site as we focused the majority of our banding efforts at this location across all seasons. This was also our only trapping site in 2021.

At Branched Oak SRA, we operated two stations simultaneously in two different areas of the SRA on opposite sides of the lake separated by 2.8 km (1.75 mi). Trapping stations included an array of two 12-meter mist nets (60 mm) centered on a nearby speaker (JBL Flip 5) playing NSWO calls on a continuous loop. Trapping stations at Branched Oak SRA (N 40.9832, W 96.8864 and N 40.9581, W 96.8805), Pawnee Lake SRA (N 40.8419, W 96.8791), Conestoga WMA (N 40.7602, W 96.8711), and Oak Glen WMA (N 40.9674, W 96.9898) were all located in areas of mixed woodland that included both deciduous trees and shrubs, as well as eastern red cedars (*Juniperus virginiana*). Playback began ~30 minutes after sunset each night of operation and lasted for 2-4 hours each night. Net checks occurred at 30- to 45-minute intervals.

Results

We operated trapping stations for 22 evenings and totaled 153 net hours over three seasons from mid-October to mid-November in each year. The earliest date we began our seasonal trapping efforts was 15 October (2020) and the latest date we opened was 22 November (2021). We operated for 5 nights over 21.5 net hours in 2019, 10 nights for 82.5 net hours in 2020, and 7 nights for 49 net hours in 2021. We operated trapping stations at Branched Oak SRA for 18 nights, Pawnee Lake SRA for 3 nights, Conestoga Lake WMA for 1 night, and Oak Glen WMA for one night split with Branched Oak SRA (5 November 2020).

We banded a total of 32 NSWOs and 2 Eastern Screech-Owls (EASO, *Megascops asio*) over three years. Capture totals by year and age are summarized in Table 1. We banded 2 NSWOs in 2019, 20 NSWOs in 2020, and 10 NSWOs in 2021 (Table 1). We banded 23 Hatch Year (HY), 8 Second Year (SY), and 1 After-second year (ASY) NSWOs of: 22 females, 3 males, and 7 individuals of unknown sex. We banded 2 HYs in 2019, 17 HYs in 2020, and 4 HYs in 2021.. Twenty-seven NSWOs were banded at Branched Oak SRA, 3 NSWOs were banded at Oak Glen WMA and 2 were banded at Pawnee Lake SRA (Table 2). We did not capture any NSWOs at Conestoga Lake WMA.

When considering data from all three years of our study collectively, NSWO migration in eastern Nebraska peaked during the first two weeks of November (Fig. 1). Our two most productive capture days at one site were 2 November 2020 and 2

November 2021, when we banded 6 and 5 NSWOs respectively at Branched Oak SRA. Our earliest capture was on 15 October 2020 when one NSWO was banded, and our latest capture was 22 November 2021, also with one NSWO banded (Fig 1).

Table 1. Capture summaries for Northern Saw-whet Owls (NSWO) for three years of fall migration trapping around Lincoln, Nebraska.

Year	Total banded NSWOs	Birds per net hour	Hatch Year (HYs)	After hatch year (SY or ASY)
2019	2	0.09	2	0
2020	20	0.24	17	3
2021	10	0.20	4	6
Total	32	0.21	23	9

Table 2. Number of Northern Saw-whet Owls (NSWO) captured at each site during each year and total number of net hours at each site ( ).

Year	BOL SRA	Pawnee	Conestoga	Oak Glen	Total Banded
2019	1 (13)	1 (8.5)	NA*	NA*	2
2020	16 (65.5)	1 (8.5)	0 (4)	3 (4.5)	20
2021	10 (49)	NA*	NA*	NA*	10
Total Birds	27 (127.5)	2 (17)	0 (4)	3 (4.5)	32

**NA = not applicable; did not trap at this site during that year*

Discussion

After three consecutive seasons documenting NWSO migration in eastern Nebraska through targeted banding efforts, we have improved the understanding of this species' occurrence during fall in eastern Nebraska. Our first NWSO banding season in the fall of 2019 established that this species does in fact migrate through our region, at least occasionally and in low numbers. The relatively large numbers overall and high proportion of HY birds in 2020 indicated that local numbers increase in kind with region-wide irruptions and large-scale migration events, as multiple stations across the Midwest and eastern U.S. also documented relatively high numbers during what appeared to be a NSWO irruption that year (Brenner and Jorgensen 2020, Drilling 2020). The 2021 season showed that NSWO may also be relatively numerous during a (presumed) 'non-irruption' year. The combined three years provides a better

understanding about this species' occurrence in the eastern half of the state and specifically demonstrates this species is a regular and not rare fall migrant away from the Missouri River. Furthermore, the fact that we captured NSWOs at 3 sites and 4 different trapping stations indicates that migrants of this species may use a range of sites containing mixed woodland habitat during fall migration and are likely to be found beyond just the trapping locations used in our study. This is also supported by the success of the only previous fall banding study in the state which occurred in Hall County in 2004 (Kim 2005).

The totals from all seasons provide additional evidence that there is a brief migration window in central-eastern Nebraska for NSWOs from mid-October to mid-November, with a definitive peak in movements in the first week of November (Fig. 1). We captured six owls (60%) in 2021 during this timeframe, and over the irruption year of 2020 we captured the majority (n = 16, 80%) of owls within this timeframe as well. This peak could extend into the second week of November during some years, and this would encompass nearly all our NSWO captures (n = 25 of 32, 79%) over the past three years. Additionally, only 45% of our total trapping effort (68.25 net hours) was within the first two weeks of November, yet we caught nearly 80% of NSWOs during this time. Kim (2005) also banded the majority (n = 11, 79%) of NWSOs in that study during the first two weeks of November. Trapping nights on which the most NSWOs were captured were during the first week of November across all seasons.

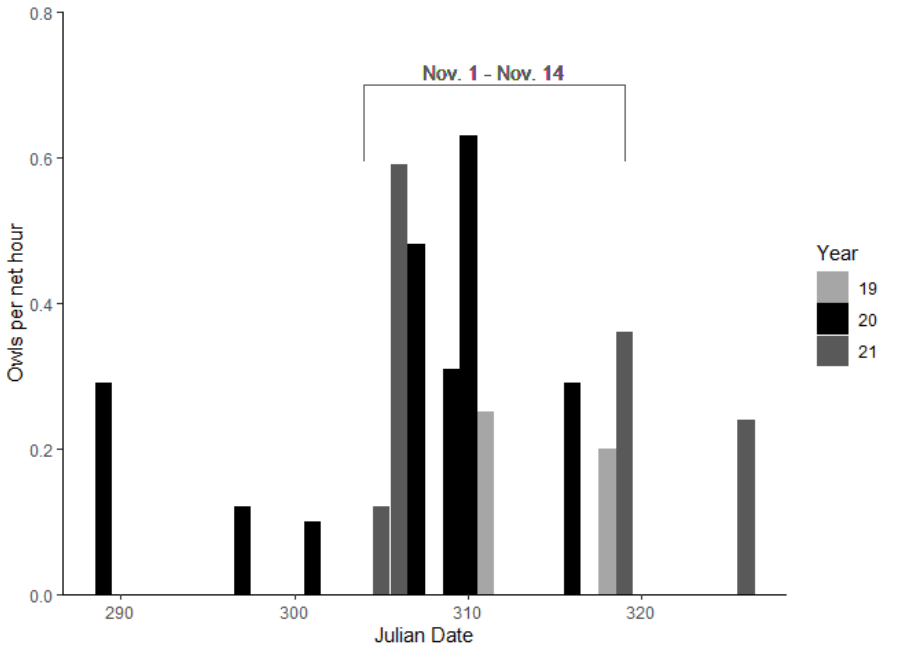

Figure 1. Northern Saw-whet Owls banded per net hour by date from 2019 (light gray), 2020 (black), and 2021 (gray) in eastern Nebraska. The brackets delineate the first two weeks of November, the apparent peak for NSWO movements in eastern Nebraska.

Our capture rates between an irruption (2020; 0.24) and the following year (2021; 0.20) were similar, but it was still higher in 2020. We operated for fewer nights in 2021 (7) compared to 2020 (10), so it is unclear if the capture rate would have been lower if we operated for more nights, particularly outside the peak migration window. However, the age ratios between these two years were different. During the 2020 season, the overwhelming majority of NSWOs were HYs (85%, Brenner and Jorgensen 2020). In 2021, we caught more AHY birds compared to HYs (40%, Brenner and Jorgensen 2021). The Kim (2005) study in 2004 also occurred during a non-irruption year (Brittain et al. 2009, Duncan et al. 2009), and likewise only 29% of birds banded in that study were HY. The higher catch rate of AHY birds to HY birds in 2021 provides additional evidence that 2020 was indeed an irruption year for NSWOs. In addition, the Hitchcock banding station in western Iowa reported higher than average numbers in fall 2020 (Jerry Toll, personal communication).

Eastern Nebraska is within the larger overall region where breeders and young produced at points farther north during irruption years will likely migrate to and through. While we were unable to catch any birds banded outside of our station (i.e. foreign recaptures), the noticeable increase in captures and heavily skewed HY age ratio in 2020 points to a likely northern (central Canada and upper Great Lakes) origin for the majority of NSWOs that migrate through the region in autumn. What is interesting about this fact is that in north-central and western Nebraska, NSWOs are an uncommon breeder (Silcock and Jorgensen 2021) and conceivably do not experience the same timing of boom-bust cycles, which are a consequence of prey availability, as more northerly breeders do (Duncan et al. 2009). From 2012-2017, multiple nestlings and adults were banded in the Panhandle and northern Nebraska during the breeding season (Molhoff 2018), but there have been limited banding attempts during autumn migration in this region. Thus, it is unclear whether there is a movement of NSWO in western Nebraska (e.g., Panhandle) that is similar to the migration observed in eastern (this study) and central Nebraska (Kim 2005). Breeding densities also appear to be irregular across the state both by location and by year (Silcock and Jorgensen 2021). More work needs to be done on NSWOs in western Nebraska to establish the movement patterns and potential similarities or differences between autumn movements in the eastern and western portions of the state.

The winter or overwintering status of NSWO in eastern Nebraska away from the Missouri River valley also remains undefined and a priority for future research, as our trapping efforts did not extend into December and January. There are few scattered winter reports from eastern Nebraska, with fewer than 5 NSWOs documented over the past 20 years from Burt, Lancaster, and Antelope counties (eBird 2021, Silcock and Jorgensen 2021). Considering the regular occurrence and numbers over the fall migration period established by the recent banding efforts detailed here, increased efforts targeting NSWOs during the winter would be valuable and would continue to improve our understanding of this species occurrence and distribution in eastern Nebraska.

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